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THE RESEARCHER IN SCIENCE[1]

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IT is the custom, at this time, for your president to sing his swan-song and make as graceful an exit from his high office as his natural urbanity—or lack of it—will permit. As retiring president I have chosen the theme of The Researcher in Science for the remarks which I have to make. I may say at the outset that they are intended, not for the veteran researcher, not for the blasé professor who has been bored into dumb, unresisting endurance by an endless succession of such addresses, but they are directed to our newly elected members.

To you, our novitiates, this evening is devoted. Yours is a sacred trust. For it is to keep the heart of science throbbing and to see that this mighty, man-made giant, blind and ruthless of itself, is devoted to the safety and the progress of civilization. In your hands and in the hands of those who come after you it is destined to save or to wreck the world, depending upon the outlook you give it, the motives you instill. The terrible catastrophe of science turned to the destruction of man has been vividly before us during the past few years, and what we have already experienced is but the prelude to what will happen if a later war is to be fought.

You are to be the leaders of to-morrow and you should get a clear-eyed vision of the fact that a heavy responsibility is to be laid upon you. It is no less than the guidance of civilization. Human society has become so complex that no longer can its conduct be entrusted to the man in the street. It must, if it is not to prove the colossal failure of all time, be delegated to the expert. Without intent to flatter, I wish to impress you with the distinction of your position. You are a chosen few from the large number of students of science in our great university. You have been selected because of promise. Your sponsors believe that they have detected in you the divine spark of creative ability which means new discovery, new understanding, new accomplishment in the realm of nature, promise of leadership. And while I want you to feel the honor of this choice, I desire still more that you realize the responsibility it places upon you. It means that in entering Sigma Xi you are pledging yourself to live up to your full capacity. Your motto becomes *noblesse oblige* no less surely than this became the motto of the born nobleman in the days of knighthood. High ability unquestionably means increased obligation to make the most of that ability.

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[1] An address before the Wisconsin chapter of The Sigma Xi.

The emblem of science is the question mark. If you feel no compelling urge in you to know the how and the why of things, then you are not destined to be a scientist; if you have not the desire in your heart, not only to discover truth but to follow it wherever it may lead, and to turn it to the betterment of your fellowman, then you are not worthy of being a scientist.

In world and national affairs if anything is to be read certainly from social and industrial conditions to-day, it is the truth of the Biblical maxim, "Ye are part one of another. * * * For none of us liveth to himself and no man dieth to himself." It is becoming clearer every day that part of the world can not be in distress and the rest carefree. This truth ranges all the way down from the major to the minor affairs of modern life. Particularly in a democracy it is obvious that all must stand or fall together. In the material things of life, for instance, it is being driven home to us daily through the pinch of shrinking purses and annoying inconveniences that we can not exist indefinitely under the pressure of either the profiteering parasite or the greedy laborer; that we can not have an eight hour day in town and a twelve hour day in the country—a fat daily wage in the one place and a lean one in the other. It is equally plain in the sphere of intellect and good taste that we can not have a cultured aristocracy and a boorish proletariat, a group of exclusive intellectuals intent only upon their own cultivation, and a mass of ignorant "hewers of wood and drawers of water." Society as a whole must have a favorable attitude toward the projects and teachings which result from the concentrated endeavor of men of high mentality; otherwise little can be permanently accomplished. This means that not only must the scientist make his discoveries, but he must carry the public with him if he is not soon to reach the limit of public support. As scientists of the future, then, you will not only have to make researches but you must keep the public educated to the value and the necessity of your research.

As a matter of fact, keeping the public posted on the progress of science is, in my estimation, not such a hopeless undertaking as some of our scientific Jeremiahs would make out. I fully believe that no really great scientific discovery has ever been made in the past or is likely to be made in the future which can not be stripped of its technical jargon and reduced to terms that, in its broader bearings at least, render it intelligible to the ordinary, educated citizen. I am one of those incurable optimists, moreover, who believes that to interest the layman, every new discovery in science need not have some obvious practical use attached to it. Nor do I believe that appeals for popular support need to be based on the economic aspects of science only. For once, at least, I should like to see some one with the knack of clear presentation and a conviction of the justice of his cause, go before the public with the direct plea of science for its own sake. I believe that the appeal would meet with a cordial response. It is so easy to show that all truth must in the long run redound to the advantage of man in other than material ways, that we lose much of our effectiveness when we confine our arguments for support to those aspects of science which mean merely a fuller purse or a fatter paunch, a more profitable mine or a more effective machine.

We hear not a little in these days about science and the humanities—that is, we hear not a little about them from the professional humanists. The word "science" in this setting is sometimes spoken with a sort of haunting fear as though the downfall of beauty, sentiment, and poesy were at hand. Science and these elusive entities vaguely termed the humanities seem to be regarded as in some way antipodal and antagonistic. To be sure we are told by Trench that the Romans meant by "humanitas" the highest and most harmonious cultivation of *all* the faculties and powers, but their modern successors seem to have changed the inclusive *all* to the restrictive *some,* that is, they apparently exclude the faculties and powers which have to do with science.

When a scientist, seeking enlightenment, makes a determined effort to lay hold upon the idea labeled "humanities," in the broad modern usage of the term, he comes back at last with such morsels as these: cultivation of the emotions and perceptions; interpretation of the soul of man; interpretation of past human experience, emotional, rational, etc.; elevation and refinement of taste; knowledge of human nature as revealed in literature and history; development of ideals; interpreting ideals of beauty; culture.

He may be a bit puzzled by the indefiniteness of his catch, but still all of the conceptions have a familiar look and feel, and he begins to wonder just why they are regarded as the exclusive prerogatives of the non-scientific. He has encountered them all in literature and even more vividly in his attempts to further the cause of humanity by solving the problems of nature. Just because he has an ineradicable conviction that the universe is intelligible if he can only discover enough links of the chain of cause and effect, and is bending his chief efforts toward working out this faith that is in him, he fails to see just where he falls short in his desire to cultivate his emotions, develop ideals, refine his taste, and interpret the soul of man. He has thought all along that these were some of the important things he was doing. In fact he would, I suspect, define the main objects of education about as follows: to learn how to extract knowledge not only from the past, but also from the things around us, and how to use such knowledge; to learn to weigh evidence that we may know how to deal with facts and to evaluate the conclusions of others; to gain understanding of the fundamental laws of nature that we may work in harmony with, rather than fall a prey to them; to learn to express our thoughts clearly, forcibly, and with a reasonable degree of grace; and to form character and develop an intelligent appreciation of the things which enrich and refine life. To be sure, he does not work much through intuition or pure fancy, or subservience to authority, and he looks somewhat askance upon products of such an origin. He believes furthermore, that the world of the emotions which, I suspect, we unconsciously imply when we talk of the humanities as consoling us in adversity or revealing human life and feelings, is likely to prove an untrustworthy guide unless grounded upon the hard substratum of objective facts. He makes use, for the most part, of what he terms the method of science.

With its mode of procedure in mind, Huxley once defined science as "trained and organized common sense." The method of science is not, then, some abstruse system which is being expounded, nor a recently discovered panacea for mental aberrations. On the contrary, it is as old as the time when a mind first existed capable of distinguishing the relations of things. So common is it that, whether merchant, mechanic, child or scientist, we use it in a simplified way in nearly all our daily occupations. The method has been expressed in words in one form or another by many logicians and educators, that we might, by focussing our attention upon it, recognize its value more clearly and use it for the more economical guidance of our minds. The principle when thus formulated becomes a sort of handrail to our mental stairway which keeps us from tumbling down into the realm of inanity, illusion and superstition. It is one of those great modes of mental activity which, more or less unconsciously, all follow, but which, like steam in a cylinder, become power to a purpose when followed consciously.

When he invades the realm of the humanists, the prying scientist soon discovers that these self-appointed arbiters of culture and humaneness are not in agreement among themselves as to what is the Simon pure brand of their ware. Seemingly, one has almost as much choice in alternatives as he has of styles in theosophy. He finds such major labels as classicism and romanticism together with a whole host of subordinate ones. Clearly, the humanists still have some time to bicker among themselves, apart from that spent in decrying the gross materialism of science and weeping over the vanishing auras of culture. I say auras because, as stated, you can never get them to agree on just what the particular aura is that is being lost.

After one becomes a bit acclimated to this rarified atmosphere one makes the interesting discovery that the real creators in this realm, the poets, philosophers and makers of *belle-lettres,* are not the complainants. Scarcely any one more than the poet, in fact, has made avid use of the findings and doings of science. One needs but to pick up his Tennyson, his Browning or his Kipling to verify this to the full.

But let us admit at once that some scientists are crass, plodding specialists who have neither breadth of vision nor depth of soul. And let us also express the suspicion that some humanists belong in an equally narrow, uncompromising class. Just as there are beetles whose sole place in the scheme of nature seems to be to hunt up dead mice and other small lifeless creatures and either devour or bury them, so there are individuals, apparently, whose idea of culture is the devotions of one's life to devouring the fragments of various dead languages, not with the idea of revealing to their less accomplished brethren whatever there may be of valuable thought or sentiment concealed there, but for the mere joy of the feast. Now no one will deny the useful part the sexton beetle plays in the world, nor does any one doubt the great service the classicist can really do for us when he stops tinkering with the mechanism of language long enough to reveal to us some of the great thoughts conveyed by it. Neither would any scientist quarrel with even the classicist given over entirely to necrophilism if the latter did not keep on insisting that his is the only real portal to culture and beauty.

Am I tilting against a man of straw? Let me cite a specific example. Some time ago I was walking along a ravine through a beautiful park with such an aesthete of classicism. The prevailing trees of the vicinity were giant beeches, and with their fresh new leaves, gray trunks and drooping branches they were a joy to the eye. The ravine itself was bordered with a profusion of the lesser trees and shrubs of the woodland. A shower had just passed and the drops of water still clinging to the leaves flashed back the gold of the late afternoon sunshine. Many of the choicer early spring flowers still lingered in the depths of the ravine—the bloodroot, the wild ginger and the trilium. The evening song of the woodthrush was all around us and a specimen of the rare hermit thrush shyly glided through the underbrush. A trim fox-sparrow eyed us pertly from beneath a nearby shrub. One good deep breath of the newly washed air was like a fresh draught of life. Upon remarking on the beauty of the scene I was met with the rather bored rejoinder, "Yes, but for it to be really beautiful there ought to be pieces of statuary here and there among the trees, and the ruins of a Grecian temple visible in the distance." Then with eyes bent to the bridle-path along which we were strolling he babbled on of beauty.

Verily, if this be a fair sample of what classicism yields, then in preference to it I suspect most scientists would cry, "Back to intellectual Nirvana and an instinctive life with the creatures of the wilderness!" Certainly the picture of the beast-world as Walt Whitman paints it is far more alluring:

> They do not sweat and whine about their condition,
> They do not lie awake in the dark and weep for their sins,
> They do not make me sick discussing their duty to God,
> Not one is dissatisfied, not one is demented

With the mania of owning things;
Not one kneels to another, nor to his kind that lived thousands
of years ago;
Not one is respectable or unhappy over the whole earth.

Fortunately, however, my example is not a fair one, but it is no more unfair than those you see exhibited not infrequently to typify the scientist. Such a classicist demands attention only because of the assiduity with which he fights the intrusion into our educational programs of anything bearing the mark of science, although he himself is often innocent of any knowledge of the subject. It should be well understood that there is no quarrel with classicism itself. Many scientists have a high regard for both Greek and Latin and wish most heartily that their students had had some training in one or both. Aside from the question of other values, the single one of inculcating something of the significance of words is certainly one that appeals to most teachers of biology, for now-a-days the simplest technical term, etymologically considered, is to most of our protégés, as one of my students put it, "only a funny noise." For purely selfish reasons, if for no other, I for one, should like to have students come to me with some knowledge of Greek and Latin roots, and practice in making derivations.

There is another type of less classical demeanor which merits passing attention. Fortunately again this type is relatively rare, though it makes up in obnoxiousness what it lacks in numbers. It professes humanism rampantly, though I suspect that real humanists would disclaim it. It deserves only such diagnosis as will enable us to avoid confusing it with men of real culture and discernment. Like the wise men of Biblical tradition, not infrequently it comes to us out of the East, shedding sweetness and light at every stride. It invariably pronounces *b e e n*, *bean*—lovingly and lingeringly, as though culture sat enshrined in this single word. It is fond of discoursing on the ideals of culture at, let us say, W— University compared with ideals at X— University, from which it sprang; always, of course, to the disparagment of the former. If music, art, literature or philosophy is the theme of conversation, it is always ready with an authoritative dictum—its own—of what's what or who's who in these realms. In its defense, the plea may be made that usually it is young, and presumably it dies early, for it is rarely encountered after its fortieth year. If you meet it, don't be perturbed by its strictures on science; science will survive.

As he listens day by day to the diagnosis of the situation at the hands of his humanistic friends, the scientist hears more frequently perhaps than any other, the word *culture*, and gradually the conviction arises that humanists regard culture and humanism as practically synonymous terms. He suspects, moreover, that some of them feel, deep down in their hearts, that they have some sort of monopoly on appreciation of the thoughts, deeds and motives of the cultured world of to-day and yesterday. The implication seems to be that in turning to science the misguided one is somehow missing the refinements of life. If you are to believe them, apparently, the scientist can not, in imagination, "wander lonely as a cloud that floats on high o'er hill and dale" because to this literal mind a cloud is only vaporized water, and inanimate things can not be lonely. Nor can his heart dance with the daffodils because strictly speaking *Narcissus pseudo-narcissus* does not dance.

When the wind is low and the sea is soft
And the far heat-lightning plays
On the rim of the west where the dark clouds rest
On a darker bank of haze

should remain a meaningless jumble to him because his mind must inevitably be distracted by the fact that, strictly speaking, the west does not possess a rim. It can not be sweet for him

——to hear the faithful watch-dog's honest bark
Bay deep-mouthed welcome as we draw near home

because, presumably, he regards the dog as only so much laboratory material. If by some mischance he wanders into Southern Italy, he can not be struck with the symbolism of the asphodel, "pale flower of Hades and the dead," which riots over the crumbled walls and around the deserted temples of Paestum, because he must be preoccupied with the knowledge that the asphodel is a plant with fleshy fasicular roots, tufted radical linear leaves, long racemes of lily-like flowers on scapes, and that it is a perennial herb of the family Liliaceae. Besides, there is a suspicion that Paestum, far from having a romantic history, was an ordinary swampy settlement from which the inhabitants were driven by the onslaughts of malaria. Again, his mind must be closed to impressions pictured in the mystical blue lights of unusual fancy—as by Hawthorne in literature or Grieg in music—since fancy is not reckoned as a tool of his trade.

However, the scientist is very likely to meet these implications with the challenge, "What is your evidence, and by what authority have *you* become mentor?" Or in the query of the Israelites to Moses, "Who made thee a prince and a judge over us?" Have you had equal training in the sciences and the humanities, or are you presuming to pass judgment in the matter without really ever getting into the spirit of modern science? In listening during the last twenty-five or more years to the perennially recurrent debate over the relative educational importance of science and the humanities, or more narrowly sciences and languages, I have always been struck by the fact, apart from the intrinsic merits or demerits of the case, that many of the scientists had a reading knowledge of French or German or both, and could boast at least a passing acquaintance with Greek or Latin, while their opponents rarely knew any science through direct contact in laboratory or field. In fact, in not a few instances the crowning glory of the latter, in their own estimation at least, appeared to be that they had kept themselves unsullied from that world of unrighteousness. Some of them seemed not to have even an inkling of the fact that to understand science is not merely to be aware of or experienced in its material achievements; that it is not only ability to use its tools and on occasion express one's self in the abbreviations which constitute scientific terminology; but that it is also to see in it the struggle of the human mind toward new concepts of nature, and to realize the place of such concepts in the fabric of civilization.

Science has, indeed, a much broader significance than application to immediate ends only. To level one's whole effort to meet the shifting needs of present occupations is, so far as true progress is concerned, clearly suicidal. Science should never be regarded as a mere commodity or means of subsistence. Human progress requires application of our knowledge, to be sure, but we must never lose sight of the great fact that discovery and explanation must precede application. Value of mind must always come above value of money and the first question of the scientist should be, not "Is it useful?" but "Is it true?" If true, then *pari passu* it is useful.

The conventional distinction between pure and applied science is in fact partly academic. A vast proportion of the material advantages of modern civilization rests on results obtained by the scientist unmotived by the immediately practical. Perhaps no conquest of nature is more impressive than that of wireless telegraphy, yet this utilitarian accomplishment was made possible only through the discoveries of Professor Hertz, a pure scientist, in his studies on light and electricity. On the other hand, perhaps nothing has done more to stimulate new researches than has practical wireless telegraphy. Almost any schoolboy can to-day cite striking instances of economic applications of principles or facts discovered without any thought of their utility, and any technologist will tell us that he can not scrape through even the veneer of his practical problem before he heads full tilt into countless other problems which require all varieties of science, pure, impure and mixed in their solution. Thus even the most thoughtless can easily see that to interfere with pure science is to kill the goose that lays the golden egg.

However, I would not belittle the part that our daily bread plays in fostering even the humanities. According to Westermann, the prosperity, and with it the culture of Ptolemaic and Roman Egypt, waxed with increase of wheat production and waned with its decline. Upon the passing of the extensive system of irrigation which had wrested fertile lands from the desert and maintained them at a high degree of productivity for hundreds of years, the desert claimed its own again, and the brilliant intellectualism of that ancient world vanished.

Not long ago, I heard a historian express his disapproval of a contemporary with the statement that B— was not a historian but a scientist, thus revealing his own conception of a scientist as a mere collector of facts. Instantly there flashed up in my mind the memory of a revered teacher of my young manhood, who, though untiring in his quest for necessary facts and meticulous in his demands for accuracy, held before us the constant reminder that, in his own words, "fact knowledge is the fool's paradise," and that "an ounce of ability to turn facts into general ideas is worth tons of information," and I reflected that my friend the historian still had much to learn about the true spirit and significance of science. It so happened that within less than twenty-four hours a scientific colleague expressed the idea that C— was not a scientist but a mere historian; that is, presumably, a chronicler of events. And I had opportunity to reflect again; this time to the effect that the scientists no less than the historian may be afflicted with seriously myopic vision when he views the other man's domain.

And is not this emblematical of the whole difficulty? Each knows too little of the other's point of view; each misunderstands the other's motives and accomplishments. This is a malady of world-wide range which is not restricted to the supposed conflict between science and the humanities. As we have already seen, it is common within the humanities themselves, and it certainly is prevalent within the sciences. Even in so restricted a realm as that of music we discover no end of disagreements and miscomprehensions. In looking through a reminiscence of Tshaikovsky some time ago, for instance, I was impressed by the fact that although this master of tone-drama—creator of the somber *Manfred* and of the melancholy *Symphony Pathétique*—admired Wagner personally, he expressed his utter inability to grasp what this great artist was trying to do in his music drama. And toward Brahms, who, because of his adherence to established forms, had unwittingly become the champion of the anti-Wagnerian party, Tshaikovsky reveals an actual antipathy, saying that Brahms coquets with the intricacies of musical composition to hide his poverty of ideas. Yet Brahms is almost universally admired by other technical musicians and is regarded as one of the greatest creators of music which is original, beautiful, and of faultless form. With such disharmony of opinion in what is supposed to be the most harmonious of the arts, is it any wonder that the place of science in the realm of human culture may be variously appraised by different cultured people?

Even when we speak or read the same words we may understand by them very different things, since we are almost sure to impute to them meanings derived from our own mental content. How easily this mistake can be made was brought vividly to my attention only a few days ago. In an idle moment I had picked up the volume of Thomas à Kempis "Of the Imitation of Christ," and was sampling it here and there. In Chapter 3 of the first book, I chanced upon the expression "And what have we to do with genera and species? He to whom the Eternal Word speaketh is delivered from many an opinion," and came up with a start. To the modern evolutionist, that could only be an echo of the Darwinian controversy, and yet as a matter of fact the volume in question was written in the early part of the fifteenth century, three hundred years before Linnaeus led us toward the modern usage of the words genus and species, and over four centuries before Darwin was born.

It is to a certain extent a matter of opinion, of course, as to what constitutes culture; but in the main, many educated people of to-day will agree that the best culture is that subtle attribute which comes with proper education, simultaneously quickening the intellectual, the moral, and the esthetic sides of man's nature. It is not learning alone, but learning refined into wisdom and intelligent social activity. Matthew Arnold's familiar definition of it as "the study and pursuit of perfection" is known to you all. But he did not limit it to pursuit, for he said we are justified in the quest for perfection only "to make it prevail." His idea of culture was, then, not only acquisition of knowledge, but also its utilization for the betterment of man.

Are we essentially more cultured, if in fancy we watch some goat-legged god go capering through the pastures and forests or along the streams of Arcadia piping to the wood nymphs, than if we actually go into the woods and along the streams in search of our friends in feathers or fur, watching their home-making, learning their habits, understanding the part they play in nature, enjoying their beauty of form, action or song? Are we necessarily more learnedly, ethically or esthetically employed when we are gazing down through the portals of a borrowed mind—say Dante's—into the murk of hell, or ascending with him through the seven planetary heavens to the empyrean, than we are when striving to analyse the obscure motives of man in terms of the behavior of lower animals where many of them stand unveiled, or in studying the part living things play in the world, and man's relation to them, so that his place in nature shall not always remain a sealed book to him? Each type of occupation unquestionably has its own value. Dante, so aptly termed the "voice of ten silent centuries," depicts allegorically the wrestling of man's soul with the problems of human existence; science represents the wrestling of man's reason with the world as it is, to the end that human existence may become based less on fantasy, more on fact.

If proper balance of tone, contrast and color are to be secured in a great orchestra, not one family of instruments—strings, wood-winds, brass or percussion—can be dispensed with. Think what a hiatus would result between strings and brass if the wood-winds were lacking; or if even the horns, which in orchestral usage merge the wood-winds with the harsher brass, were missing. What could take the place of the trio for horns in the "Eroica," or the horn solo in the scherzo of the "Pastoral" Symphony, or the well-known passage for four horns in "Der Freischutz"? The peculiar tonal quality of each separate instrument, indeed, whether considered individually or in combination with other instruments, is essential to the finished effect. The expressiveness of the bassoon, bass of the wood-winds, is inimitable in certain sustained melodies like that given to it in the Weber Mass in G, "Agnus Dei"; so, too, is its drollery in the hands of good old Father Haydn, or its ghastliness in Meyerbeer's resurrection of the nuns, or Handel's scene between Saul and the Witch of Endor. What else could impart the spirit of gayety, or, on occasion, of melancholy, that that autocrat of the orchestra, the oboe, does? Or what can pander more to savagery in musical taste than the yelping, braying saxophone, hybrid of reed and brass, which so intoxicates our modern devotees of "jazz"? The point I would make is, that just as a great diversity of instruments of distinctive individual and group qualities must be combined to secure the marvelous effects of the symphony orchestra, so the blending of a wide range of sciences and humanities is indispensable to well-balanced modern culture.

Thus no one aspect of learning is sufficient. The study of science in some form should be accorded a prominent place, however, because of its obvious bearing upon the principles involved. It is the most direct of all learning, and from the very necessity of obtaining correct knowledge through personal contact with the facts concerned, it engenders in large degree the ability "to make it prevail." Training in science, therefore, must demand recognition as one of the fundamental components leading to that perfection which, with Arnold, we may recognize as the goal of culture. "Perfection * * * is a harmonious expansion of *all* the powers which make the beauty and worth of human nature, and is not consistent with the over-development of any one power at the expense of the rest."

Even if we choose such aspects of culture as art, we can not escape the fundamental necessity of accurate observation and clear reasoning—the very essence of science—and this is as necessary to literary art as to other forms. For before we can have art in literature, we must first see the truth, then state it accurately and clearly. Walter Pater, one time apostle of precision and fitness in style, says, "Truth! there can be no merit, no craft at all, without that. And further, all beauty is in the long run only fineness of truth." That accuracy in the use of language which must result if one records his observations faithfully, then, must be one of the foundation stones upon which literature as art is builded;

for if we are to believe this critic, fine art in literature results only from the writer's effort to transcribe the essence of the truths which he perceives; not necessarily, to be sure, the actual specific fact, but "his sense of it," and the result is "good art in proportion to the truth of his presentment of that sense."

We sometimes hear the curious assertion that training in science tends to destroy the powers of imagination, that it renders one prosaic. But what has suggested any of our great laws or principles in the world of science, if it has not been a legitimate working of the imagination? It was the imagination of Sir Isaac Newton that led him from the simple perception of a falling body to the great law of gravitation, whereby we have compassed the heavens and are able to follow the celestial bodies with the precision of clockwork. It can be nothing else than the imagination which has disclosed the realm of the imperceptible molecule and atom, or in the discovery of electricity enabled us to outdo Puck in putting "a girdle round about the earth in forty minutes." Or what but the imagination, based on scientific fact, has carried us back step by step peering into the depths of ancestry till we perceive the remotest dead, and has thus enabled us to formulate the great law of organic evolution? In truth, as pointed out long ago by Tyndall in a famous lecture on "The Scientific Use of the Imagination," to science should be attributed a legitimate cultivation of the imaginative faculty rather than its destruction. To flights of pure fancy unhampered by knowledge or common sense, however, science is perhaps less cordial.

And last of all let us take cognizance of beauty, that quality which appeals to, and gratifies, our esthetic sense. Where else than in nature can one find more of that perfection of form or circumstance, of harmonious combination, which is the essence of beauty? Only one trained in interpreting the processes of nature can, in fact, see its greatest beauties. To such a one a graceful tree has a tenfold beauty unsuspected by the casual observer. It is not only a thing of symmetry and of life, a harmony of color, or a picturesque bit of the landscape; it is infinitely more. Its every attitude, every part, is a response to the wonderful energy of the universe. Locked in every leaf is the secret of creation which can wrest life from the sunbeam and embody it to our view. The very arrangement of bough on trunk and leaf on bough points to the silent struggle of each to gain the most favorable position for this transmutation of life. Its roots, prompted by an inner impulse of response to the external world, no less marvelous than that of leaf and bough, thread their way in darkness for the soil-food and water which shall later with the ingestions of the leaves form the mechanism of living substance.

From the standpoint of beauty our wild animals are not only graceful creatures suited to ornament some menagerie or zoological park;

they are not merely a delight to the eye because of form, color or action; but they are also living examples of that higher beauty to be perceived through a comprehension of the marvelous fitness of living things to their environment. One trained to read such records need not stupidly go to a natural history every time he wants to find out the essential facts about some particular animal, for the account of its native haunts, its habits of life, the nature of its friends and foes are before him in the living animal itself. The spotted coat of the forest, the stripes of the jungle or the meadow, the dunes of the desert, the whites of the polar regions, the symmetry and proportions of body, the claws or hoofs, the beaks or teeth, the position of the eyes, the characteristics of the ears, nose or jaws, in short any particular part of the body when taken with the equally obvious context to be read elsewhere in the animal, tells its unmistakable story.

To one who can interpret, the flower, in addition to mere formal beauty and fragrance, has a wonderful history to disclose of ingenious device, which reaches even to the other world of life, the world of sentient beings, and forces bee or butterfly to serve its ends. The trained observer may see, furthermore, in every spear of grass or every forest tree an emblem of triumph; for has not each through endless struggle won victory? It is the understanding of this victory which enables the seeker after truth to pry even into the very inception of all life and form, whether plant or animal, and point the path by which it has arrived at its present perfection.

And not only in the field of animate nature, but in the realm of astronomy with its romance of worlds in the making and worlds in decline, with its myriads of solar systems in incredible gyrations, yet all apparently orderly and harmonious; in chemistry with its wonderful systems of combination and exchange, of creative possibilities that beggar the lamp of Aladdin; in physics, forging ahead with astonishing strides into the solution of matter itself and of all performances of matter; in geology with its ingenious readings of the past in earth shrinkage, crust warping and climatic oscillations, with its re-creation for us of successive ages of flood and ice, land and sea, of strange monsters long since vanished; in all of these there are worlds upon worlds of beauty unsuspected by those who are strangers to the paths of science.

Thus from the standpoint of esthetics, nature becomes to the student a wonderful harmony. As he perceives something of the mechanism of the universe, how each part moves cog within cog in marvelous unity, knowledge does not reduce his emotional enjoyment, but enhances it through a higher sense of beauty.

When all is said and done, after admitting that many scientists have their crudities and some humanists their asininities, we must realize that science and the humanities have far more in common than they have apart. The old idea of conflict between them is largely fictitious.

They are or should be cooperants, not antagonists. For the most part they look toward the same problem, in last analysis the great problem of what is worth while for humanity. They but view it from different angles. And it will be a sorry day, not only for science but for civilization itself, if scientists ever lose sight of the humaner aspects of their problems. It is my serious conviction, indeed, that one of the imperative, outstanding duties of the modern scientist is to do away with what remains of the no-man's-land between these two great aspects of human culture and blend them into one. No one more than the thoughtful scientist recognizes to-day that science in the sense of mere material accomplishment, of greater accumulation of knowledge, or of more precise logic—if this be all—is futile; it must be humanized. Without the final touch of human altruism, science may easily become a soulless Moloch which will devour its own creators.

Further applications of scientific knowledge unquestionably will mean growing complexity of social organization. And our organization is already so intricate that a slip anywhere in the machinery, be it but the obstinacy of a few striking switchmen or the discontent of a handful of coal miners, may throw the whole machine into disorder. With the dependence of one upon another to which we are becoming more and more committed, serious disruptions of the system become increasingly probable and increasingly hazardous.

In his more pessimistic moods, when he ponders the trend of present economic and social conditions, the mind of the evolutionist harks back to the grotesque monsters of Mesozoic times whose very hugeness probably led to their final extinction, and he is filled with apprehension for the outcome of the human race. This much is sure, human society will need all of brotherly love, all of tolerance, all of the refinements of existence that scientists and humanists can muster jointly, if the giant organism known as civilization is not to succumb to its own intricacy.

It becomes your duty then as a part of the rising generation of scientists to do your share toward imbuing science with a soul, and one of the easiest ways of doing this is to help promote the humanities as you do your science, in every way you can. The relation of man to his fellowman is no less important than the relation of man to his physical environment. Recognizing as we companions of Sigma Xi do that research is the highest form of human activity, let us not take a narrow view of it. The goal of science and of the humanities alike is truth.

The desire for truth, indeed, is a well nigh universal human attribute. The many observances and beliefs common to all the great religions symbolize the cravings of the human mind for truth. Thus the Vedanta maintains that the final deliverance of the soul from its burden of repeated carnal existence can be attained only by the removal of ignorance. In the teachings of Zoroaster we find that chief among the "worshipful ones" who guide the forces of nature is Mithras, personification of light and truth. And as for the Buddha, his very name comes from a word which means "he to whom truth is known." More familiar still is the pronouncement of the gentle Nazarene, "Ye shall know the truth, and the truth shall make you free."

The great poet, the true artist, the sincere novelist is striving in *his* way for truth, for reality, in no less a measure than is the physicist or the chemist. And the most cursory glance into the past shows that this has been so thoroughout all history. We find Aeschylus, five centuries B. C., grappling in his poetry with a conception of the mental evolution of man. His graphic description, in his *Prometheus Bound,* of the part number and the rudiments of science played in the awakening of man from blind instinct into reason is well worth considering (translation of Elizabeth Barrett Browning):

> How, first beholding, they beheld in vain,
> And hearing, heard not, but, like shapes in dreams,
> Mixed all things wildly down the tedious time,
> Nor knew to build a house against the sun
> With wicketed sides, nor any woodwork knew,
> But lived, like silly ants, beneath the ground
> In hollow caves unsunned. There came to them
> No steadfast sign of winter, nor of spring
> Flower-perfumed, nor of summer full of fruit,
> But blindly and lawlessly they did all things,
> Until I taught them how the stars do rise
> And set in mystery, and devised for them
> Number, the inducer of philosophies,
> The synthesis of Letters, and, beside,
> The artificer of all things, Memory
> That sweet Muse-mother.

Somewhat later we note the endeavors of Plato to make knowledge and conduct go hand in hand, and in his pupil, Aristotle, we see perhaps one of the most ideal combinations of scientist and humanist in one that history reveals. Still farther down the ages we find Lucretius not only propounding a theory of the confluence of atoms into stable and adapted forms, but even foreshadowing the idea of a struggle for existence, the conception which became of such importance in the Darwinian theory. Thus, " * * * And many races of living things must then have died out and been unable to beget and continue their breed. For in the case of all things which you see breathing the breath of life, either craft or courage or else speed has from the beginning of its existence protected and preserved each particular race. * * * In the first place, the fierce breed of lions and the savage races their courage has protected, foxes their craft, and stags their proneness to flight."

With all of these, as with the scientist to-day, the unmistakable note is the quest for truth. So that we scientists in our pre-occupation with our own fragments of truth must not overlook the fact that the expressions of human emotions, character, taste, and cultivated imagination, all have their share in the finished product of our search. In fact, when we stop to consider, it is obvious that the motives for our conduct, our likes and dislikes, lie far more in the realm of the emotions than in that of the intellect. And all history implies that man can no more live without beauty than he can live without bread.

> Beauty is truth, truth beauty—that is all
> Ye know on earth, and all you need to know.

Even the prehistoric cave-man showed his craving for beauty in crude attempts at picture-making. The colored drawings may still be found on the walls of his caves. The warring, pirating Greeks bore a Winged Victory at the prow of their boat. In the Middle Ages, while the shepherds of the church were burning heretics, great artists were painting Madonnas, great architects were erecting magnificent cathedrals to the glory of God, great writers were giving voice to the tortured, struggling, inarticulate soul of humanity. Seek any period in history, no matter how sordid, how tyrannical, how merciless man in the aggregate may have become; there was always abroad somewhere in the land the spirit of beauty, the leaven of humaneness which in the end redeemed the whole.

> And where is he shall figure
> The debt, when all is said,
> Of one who makes you dream again
> When all the dreams were dead.

And we may note to good advantage also that our knowledge of such facts as these has come down to us mainly through the efforts of humanists. Without them what indeed should we know of "the beauty that was Greece and the grandeur that was Rome?" The nations themselves have long since passed into the night, but their thoughts, their motives, their accomplishments have been added to our own civilization, thanks to the tireless efforts of our classical scholars. And who shall say how much of the efforts of these scholars was science, how much humanism?

As a matter of fact, the reconciliation of science and the humanities, in spite of complainants sometimes heard to the contrary, is already in progress. This is evinced, on the one hand, in the increasing drafts the humanists are making on the methods and materials of science, and through their tacit or avowed acceptance of the worth of science and, on the other, by the spirit of greater tolerance exhibited by scientists. Even in the short period between the present and the close of the nineteenth century, one can notice a decided change of attitude on the part of science. The cocksureness and belligerency of the earlier period has softened into a willingness to reconsider evidence and a spirit of friendliness towards all types of scholarly endeavor. To-day, while his attempt to explain things mechanistically does not falter, the scientist recognizes more clearly the limits of possibilities.

The reason for his earlier attitude, however, is not far to seek. In the last century, particularly following the proclamation anew of the theory of organic evolution by Darwin and his followers, science in general, though especially biological science, suffered the fierce onslaught of the powerful leaders of the day, the clergy, who saw their authority challenged, their privileges threatened. Driven to fight this hostile element for the very life of science, the result was just what might have been expected—the exaggerated dogmatism of a Haeckel or the caustic tongue of a Huxley. The latter, with his crystal-clear style of presenting the facts of science, his bulldog pugnacity and his quick wit, was particularly effective. Now we find him urging one of his hecklers who could or would not understand what he was saying, to use the full length of his ears and he would surely understand. On another occasion, in his famous tilt with Bishop Wilberforce, he expresses his preference for a respectable monkey as an ancestor to relationship with a bigoted bishop who uses his great gift to obscure the truth. Again we hear him pronouncing the conviction that "Extinguished theologians lie about the cradle of every science as the strangled snakes beside that of the infant Hecrules." Such retorts as these show what the provocation must have been, and it requires little further exercise of one's powers of inference to discover why the science of the nineteenth century had the ring of dogmatism. Unquestionably the modern researcher has Huxley to thank for much of his own immunity from such attacks.

But to-day the clergy have come to see that a God of an orderly universe is quite as acceptable as a God of an arbitrary chaos. The educated clergyman now recognizes the importance and more or less of the significance of science, even of evolution, and is finding more than enough to keep him busy in the immediate problems of the human soul without worrying so much about its future. He is content to give us help in the present instead of hell in the hereafter. His aid in keeping the spirit of altruism alive in the world, in upholding ideals, in winning men from the fiercer passions of life, was never more needed and never more tolerantly and wisely given than it is to-day.

But as scientists we are not so much interested in the duties of some other profession as we are in our own. The only excuse I would offer for stepping outside bounds is that if we are to have perspective in our work, if we are to secure a clear vision of future world problems we must see these problems from various points of view and realize that our duty is not done, our fullest possibilities are not realized, until we have fitted our findings as researchers into this general scheme of things. To have but a narrow angle of vision is to miss most of the richness of life and much of the good we can do for our fellowman. We want to escape the type of accuracy exhibited by the literal-minded printer who, upon coming to the quotation, "Sermons in stones and books in running brooks," corrected it to read "Sermons in books and stones in running brooks."

To each of you as researchers civilization is entrusting its future. It is yours to do great deeds, to dream great dreams. And you may well remember that "the dreamer lives forever while the toiler dies in a day." To most of you will come the seemingly small, but actually the fundamentally important duty of making accurate records of observations and conclusions, together with necessary qualifications and limitations. This is indispensable as a foundation for one's own scientific procedure and is equally important as the basis of fact from which others may take up the duties of discovery after the recorder has passed away. To some of you may be given that rare vision which will enable you to weave together from the ever accumulating strands of scientific truth some new far-reaching generalization. But whatever your part, be it great or small, be assured of its dignity, of its worth, as long as it is honestly performed. You may not live to see the great poet honored more than the successful politician, nor the great scientist more valued than the wealthy trader, but you can at least throw the weight of your influence into the proper scalepan. Yours is a rare opportunity to create, to produce, and I know of no better admonition to urge upon you than this sentiment expressed in the clarion call of Carlyle:

> "Be no longer a Chaos, but a World, or even Worldkin. Produce! Produce! Were it but the pitifullest infinitesimal fraction of a Product, produce it, in God's name!"

In closing, may I urge again that for the researcher, ideals as well as achievements are indispensable to progress, and that both must often run far in advance of what for the moment may seem practical. If the world is to be ruled by truth rather than by tradition and the chance compensation of errors, you and others like you who are entering into the scientific communion of Sigma Xi must give up your life to continuous processes of thought and experimentation. Since the creative mood demands quiet, poise and concentration, you will have to make a constant fight to see that your strength and ability are not drained off by trivial and irrelevant demands into non-productive channels. You will doubtless be called upon to make financial sacrifices. And your reward? Your reward will be consciousness that you have fulfilled your real function of discovering truth, diffusing knowledge and developing ideals.

> Have I named one single river? Have I claimed one single acre?
> Have I kept one single nugget—(barring samples)? No, not I,
> Because my price was paid me ten times over by my Maker.
> But you wouldn't understand it. You go up and occupy.

And while I am quoting Kipling, I shall leave this other bit with you as voicing the real spirit of the researcher:

> Till a voice, as bad as Conscience, rang interminable changes
> On one everlasting Whisper day and night repeated—so:
> "Something hidden. Go and find it. Go and look behind the
> Ranges—
> Something lost behind the Ranges. Lost and waiting for
> you. Go!